Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

FIELD PACKING CELERY in crates, Salinas Valley, utilizing field lidding device

Celery Production in California

WILLIAM L. SIMS · JAMES E. WELCH · THOMAS M. LITTLE

CALIFORNIA AGRICULTURAL
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CIRCULAR 522

When production of celery for medicinal purposes was begun in Europe in the 16th century it was still a primitive plant, although it had been known for many centuries in the Mediterranean area where it probably originated. Cultivation of the plant for food was first recorded in France in 1623; by the early part of the 18th century there had been improvement of the wild type of celery previously transported to Italy, France, and England, and as early as 1726 the plant was being used in England to flavor soups and stews.

Today, the acreage devoted to celery in the United States alone varies from 32,000 to 37,000 acres, approximately, and the value of the national crop ranged from $45,350,000 in 1961 to $49,781,000 in 1960. California's celery harvest was worth $26,302,000 in 1961—58 per cent of the nation's total for that year, on a cash-value basis. Celery ranked fifth in value among California vegetables in 1961, with 14,900 acres planted to it.

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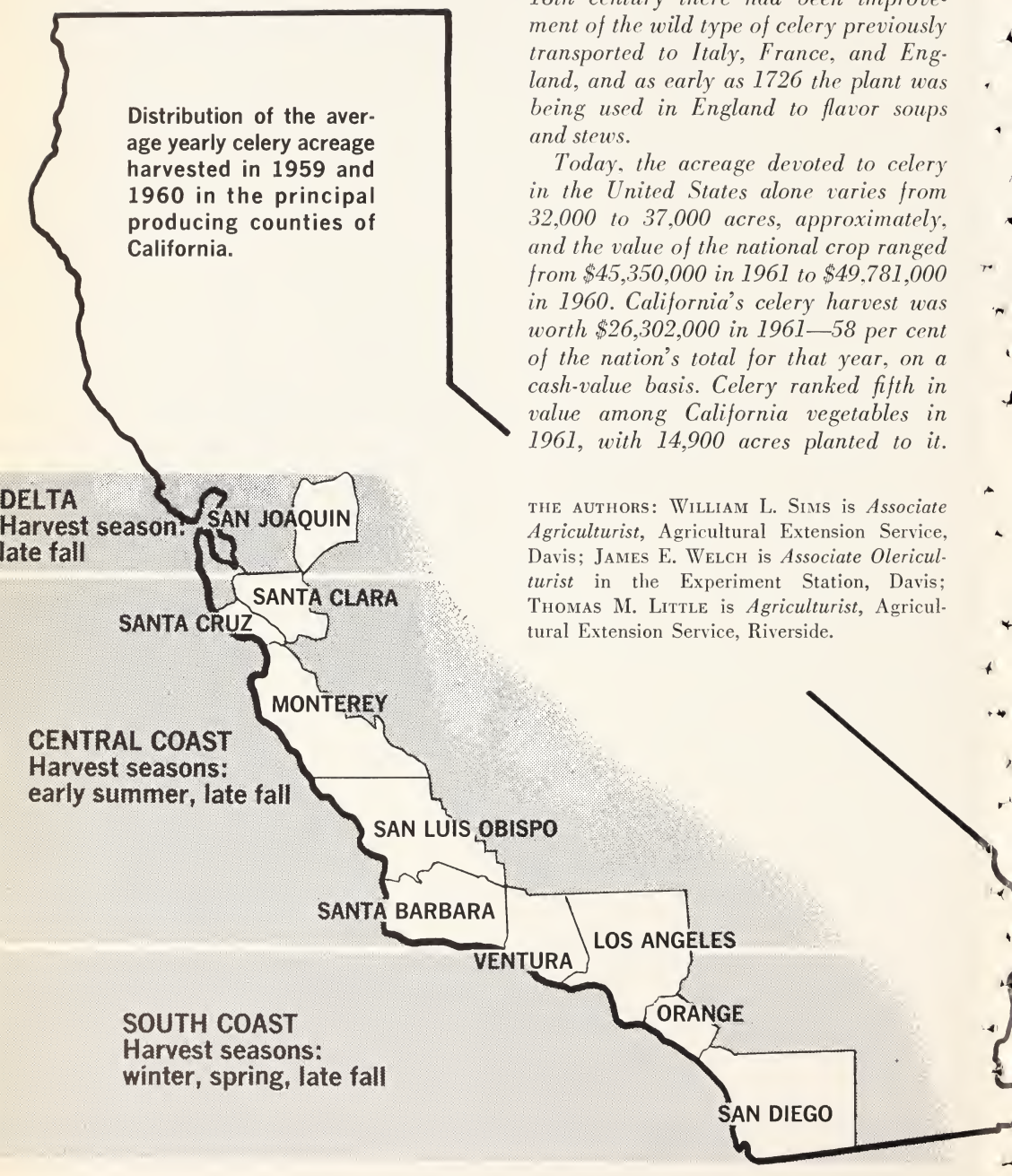

Distribution of the average yearly celery acreage harvested in 1959 and 1960 in the principal producing counties of California.

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The Plant

A brief description of celery's growth habits.

Celery (*Apium graveolens* L. var. *dulce* Pers.) is normally a biennial, although under certain conditions it develops as an annual. In the course of its usual cycle a well-developed root system, a short, fleshy crown stem, and a rosette of leaves are produced the first year. The thick, fleshy petioles, or leaf stalks, of the rosette leaves comprise the principal edible portion of the plant. Commercial handlers of celery usually refer to petioles as "ribs," "shanks," or "stems," and to whole marketable plants as "stalks" or "heads." During its second year the main stem, or seedstalk, elongates and branches to produce a shrubby plant about 3 or more feet in height. The plant bears compound clusters of small white flowers, which produce flattened, dry fruits toward the end of the flowering season.

Occasionally, celery plants develop as annuals and produce seedstalks the first season. Growers call this condition "premature seeding" or "bolting," and affected plants are unmarketable unless seedstalk elongation is slow and occurs when plants have almost reached harvest stage. Single plants which show seedstalk elongation are often referred to as "seeders." *Exposure of plants to relatively low temperatures is the main factor in bolting.*

Celery produces a well-developed root system (consisting of a tap root and laterals) when the crop is grown from seed to market maturity without transplanting. When transplanting is practiced, the tap root is destroyed and the fibrous system is comprised of a large number of adventitious roots growing from the base of the plant. A large part of the root system occupies the upper 6 inches of soil—many of the roots are within 2 or 3 inches of the surface, but some penetrate to a depth of 2 feet or more.

Climate and Soil

Celery is a cool-season crop requiring precise climatic conditions and a long growing season.

Ideal conditions for commercial celery production include a relatively cool growing season, a well-drained soil, and an abundant, uniform supply of soil moisture. The plants will tolerate considerable heat after they are established in the field, but during the last month or so preceding harvest temperatures should average no more than 60° to 70°F. Celery is damaged near the market stage by freezing temperatures.

BOLTING, OR PREMATURE SEEDING

This is a potential problem in spring-maturing California celery crops, especially in those harvested from about mid-April to mid-May, and is sometimes a problem in winter-maturing crops harvested after March 15 (approximately). Bolting can also cause losses in late June in the first fields harvested during the early summer season. Exposure to relatively low temperatures (approximately 40° to 55°F) for as little as 10 days or so near the lower temperature results in bolting when the plants are subsequently grown under favorable conditions. For this reason greenhouse celery plant growers maintain minimum temperatures above 60°F. Different celery varieties have different susceptibilities to bolting.

SOILS

Peat, muck, and loam soils are preferred for celery culture, and heavy clays are not recommended. Celery soils should be well-drained. Because celery produces 60 tons or more of fibrous material per acre, soil moisture and nutrients should always be available in sufficient amounts. The addition of organic matter to mineral soils improves both soil structure *and* evenness of supply of moisture and nutrients. Nitrogen in large amounts is needed, particularly when the crop approaches market maturity, and environmental conditions producing uniform growth should be provided. New celery growers should consult their local Farm Advisors about production problems.

Varieties and Varietal Problems

Varieties must suit season and district.

VARIETIES

Celery varieties grown in the United States belong to the golden, or yellow, class or to the green class. Commercial celery acreages in California are comprised exclusively of green varieties, of which several varietal groups, or types, are available. Types grown in California, and principal varieties grown commercially in each of these types, are listed below.

- Summer Pascal type:
  - Pascal 259-19
  - Green D5
- Utah type:
  - Ordinary Utah subtype:
    - Utah 16-11
    - Tall Utah 10-B
    - Delmar
  - Crystal Jumbo subtype:
    - Tall Utah 52-70
    - Tall Utah 52-70 H
    - Compak No. 2
- Slow Bolting type:
  - Slow Bolting Green No. 12
  - Slow Bolting Green No. 96

Utah type and, especially, Crystal Jumbo subtype varieties predominate in California celery fields. Buyers prefer these varieties to Slow Bolting and Summer Pascal types mainly because the trimmed heads are cylindrical, compact, and have attractive, well-overlapped ("shingled") petioles, a relatively large number of petioles, and good heart development. The leaflets of Ordinary Utah subtype varieties are slightly yellowish green and the leaflets of Crystal Jumbo subtype varieties are very dark, blackish green. Slow Bolting type varieties are

Bolting reduces the crop's value

THE CELERY PLANTS ABOVE were taken from two fields in the same area and were cut in half to show the effects of bolting. The plant on the left was taken from a field planted late enough in the season to avoid frost and is developing normally. The center and right-hand plants were subjected to an unseasonal cold spell and have started to develop seed stalks that will reduce their value for fresh market sale.

Table 1. Celery Harvest Seasons, Areas or Districts, and Varieties Grown, Principal Counties, and Average Yearly Acreage Harvested in 1959–60

SEASON	AREA, AND VARIETIES GROWN	COUNTIES	ACREAGE
Winter	South Coast	Orange*	1,590
	varieties:	San Diego†	1,325
	Tall Utah 52-70	Ventura*	1,050
	Tall Utah 52-70 H	Los Angeles†	615
	and some	Other counties‡	70
	Utah 16-11		
		TOTAL	4,650§
Spring	South Coast	Orange	1,300
	varieties:	Ventura	975
	Tall Utah 52-70	Los Angeles	945
	Tall Utah 52-70 H	Other counties	30
	and some		
	Slow Bolting Green No. 12		
	Slow Bolting Green No. 96		
		TOTAL	3,250§
Early summer	Central Coast	Monterey*	1,130
	varieties:	San Luis Obispo	730
	Tall Utah 52-70	Santa Barbara	255
	and some	Santa Clara	220
	Slow Bolting Green No. 12	Santa Cruz	70
	Slow Bolting Green No. 96	Other counties	45
	Pascal 259-19‖		
		TOTAL	2,450§
Late fall	Central Coast	Monterey	3,510
		Santa Barbara	1,965
		San Luis Obispo	680
		Santa Cruz	170
		Santa Clara	125
	Delta	San Joaquin†	995
	South Coast	Orange	125
	varieties:	Los Angeles	100
	Tall Utah 52-70	Other counties	130
	and some		
	Tall Utah 10-B		
		TOTAL	7,800§
STATE TOTAL			18,150

* Acreage has increased in last 10 years.
† Acreage has decreased in last 10 years.
‡ Counties with 50 acres or less.
§ Average percentages of the total acreage grown for harvest during each of the harvesting seasons in 1959–60 were: winter, 26; spring, 18; early summer, 13; and late fall, 43.
‖ Salinas-Watsonville district.

grown only when bolting might cause losses in Utah type varieties. Tall Utah 52-70 and Tall Utah 52-70 H are more attractive than Slow Bolting Green No. 12 and Slow Bolting Green No. 96, and therefore bring higher prices. Because of this, growers tend to arrange their plantings so that they can start harvesting the

Table 2. Usual Celery Planting and Harvesting Dates for Different Harvest Seasons

HARVEST SEASON	PLANTING DATES	HARVEST DATES		
		BEGIN	MOST ACTIVE	END
Winter*	Aug.–Nov.	Nov. 20	Jan.–Mar.	Mar. 31
Spring†	Nov.–Mar.	Apr. 1	May–June	July 31
Early summer‡	Mar.–May	June 20	July–Aug.	Aug. 31
Late fall§	June–Aug.	Sept. 1	Nov.–Dec.	Jan. 15

* Crop produced almost entirely in the Los Angeles-Orange County (Los Angeles and Orange counties), Chula Vista (San Diego County), and Oxnard (Ventura County) districts of the *South Coast area.*

† Crop produced almost entirely in the Los Angeles-Orange County and Oxnard districts of the *South Coast area.*

‡ Crop produced almost entirely in the Salinas-Watsonville (Monterey and Santa Cruz counties), Santa Maria-Oceano (Santa Barbara and San Luis Obispo counties), and Centerville-San Jose (Santa Clara County portion) districts of the *Central Coast area.*

§ Crop produced almost entirely in the Salinas-Watsonville, Santa Maria-Oceano, and Centerville-San Jose (Santa Clara County portion) districts of the *Central Coast area;* the Delta (San Joaquin County portion) district of the *Central region;* and the Los Angeles-Orange County district of the *South Coast area.*

above two Tall Utah varieties as early as possible, and some growers plant them exclusively, gambling that weather conditions which cause bolting will not occur.

Summer Pascal type varieties comprise only a small percentage of the California crop. Green D5, Delmar, Compak No. 2, and Slow Bolting Green No. 96 were introduced subsequent to 1957; the acreage planted to these varieties is small, and trial plantings by growers over a period of years will determine which ones will find a place in California.

• Buyers, shippers, and crop reporters usually refer to all varieties of green celery as "Pascal." When Pascal is used in the horticultural sense, however, it refers to a specific varietal type and not to all varieties of green celery.

VARIETAL PROBLEMS

The susceptibility of the Utah type varieties to bolting under certain conditions, and the susceptibility of all varieties to late blight, a disease caused by the fungus *Septoria apiicola*, are perhaps the two most serious varietal problems in California. Pithiness, a physiological disorder, often develops in the outer petioles of the popular Tall Utah 52-70 variety when the plants reach market maturity. In order to avoid losses from the spread of pithiness to inner petioles, harvesting usually must not be deferred. Thus, cutting of crops maturing during weak market periods cannot be postponed in anticipation of improved market conditions which might occur even a few days later.

Cultural Operations

Soil must be thoroughly prepared, both for direct seeding and transplanting.

PREPARING THE SOIL

Most of California's celery acreage is on heavier soils and cultural practices often vary from district to district. Fields may be disked, subsoiled, plowed, harrowed, and land planed—land planing is important for uniform furrow irrigation. After land planing, a soil treatment of aero cyanamid (800 to 1000 pounds per acre) is sometimes made to control pink rot (*Sclerotinia sclerotiorum*), and heavy applications of animal manure are often made at this time also. (See "FERTILIZATION," page 14.)

After soil treatment and fertilization, the land is sometimes disked, chiseled, and then harrowed again. Before planting, the field is furrowed or "listed" to make ridges for planting and furrows for irrigating; lister ridges may then be

Because chemical control measures and details on application rates may vary as new information is developed, the grower should refer to the annual "Vegetable Crop Pest Control Guide" put out by the University of California Agricultural Extension Service. See your Farm Advisor for a copy.

rolled with a smooth roller to make a firm bed—in some areas the beds are shaped with a spike harrow. Furrows may be spaced 24 to 40 inches apart, depending upon whether single or double planting rows are used and upon type of equipment involved.

PLANTING

Slightly over half of California-produced celery is grown from transplants, and the rest is direct-seeded. Methods of planting vary from district to district, with the Salinas-Watsonville and the Santa Maria districts being predominantly direct-seeded.

Growing transplants in the greenhouse. About 60 to 75 days are required to produce suitable transplants from seed. While transplants can be purchased from greenhouse operators, some producers of celery grow their own plants in order to help minimize production costs and to insure a supply of high quality plants.

Greenhouse plants are seeded in wooden flats measuring $16 \times 16 \times 2\frac{1}{2}$ inches which are generally filled with a composted soil-mix or a U C light soil-mix. University of California Soils Mix B with fertilizer is recommended. This is a mixture of 75 per cent fine sand, 25 per cent peat moss, and fertilizer, which can be sterilized with steam or methyl bromide. Fertilizer can be added to each cubic yard of sand and peat moss mixture as follows: 6 ounces potassium nitrate, 4 ounces potassium sulfate, $2\frac{1}{2}$ pounds single superphosphate, $4\frac{1}{2}$ pounds dolomite lime, $1\frac{1}{4}$ pounds calcium carbonate lime, and $1\frac{1}{4}$ pounds gypsum. This mixture contains moderate amounts of available nitrogen, but will require supplemental feeding within a short time. It is not composted, and may be used the day it is made. Soil in flats is firmed, especially at sides (methyl bromide or steam sterilization of filled flats may be necessary to prevent damping-off). Seed is sprinkled over soil at the rate of 1 ounce to 15 flats. Seed is then covered lightly with sterilized sand and flats are watered and covered with steam or methyl bromide sterilized burlap or coarse sand. Infected celery seed may carry spores of late blight (*Septoria apiicola*) which may be the principal source of field infection. The spores can be killed by soaking seeds in a mesh bag for 30 minutes in water at 118°F—care should be taken to prevent the temperature from rising above 120°F, as high temperature will markedly reduce seed germination.

• In 20 to 30 days the plants should be about 1 to 2 inches tall, and they are then transplanted to other flats at the rate of 100 to 110 plants per flat. In about 30 to 40 days they will be large enough for transplanting into the field.

• Before transplanting into the field, young plants are hardened by withholding moisture, and by placing them outside the greenhouse. Plants should not be exposed to temperatures below 55°F, as doing so may initiate bolting. Winter celery requires no hardening.

Greenhouse temperatures should be around 65 to 70 degrees F. Greenhouse plants often are given dry or liquid chemical or organic fertilizers, but this is not necessary when the right amount of fertilizer is included in a light soil-mix.

• If late blight appears on plants they should be sprayed with a fungicide such as zineb, maneb, dyrene, bordeaux mixture, or fixed copper. Just before transplanting into the field, appropriate insecticides may be added to the copper spray to control aphids or other insects.

The number of flats used per acre of

field varies from 350 to 400 (most growers use about 375). Field planting can be done directly from flats, or plants can be pulled and taken to the field in crates—which saves hauling of flats and thus lessens time spent repairing them.

Growing transplants in outside beds. Celery plants can be grown in open beds in summer and in cloth-covered beds (or cold frames) in winter. Beds should be located near ample water, away from weeds and trash, and on nematode-free soil which does not crust easily; soil should not have been previously planted to celery or related vegetables, such as carrot, parsley, or parsnip, because of danger from disease and insect organisms. Beds should be shaped and leveled like those used for field plantings. Three to four ounces of seed will be needed to produce the 35,000 to 44,000 plants required per acre, according to the plant and row spacing used. One acre of seedbed will produce enough plants for 15 to 20 acres of transplanted celery.

After surface of plant beds has been finely pulverized, seeds may be broadcast by hand or seeded in wide bands with small drills. Seed should be covered with not more than ¼ inch of soil.

• An irrigation should immediately follow seeding, and beds should be kept moist until plants are up—*do not allow a crust of soil to form over seeds.* Frequency of irrigation may be reduced when plants are up, but plants should be kept growing vigorously until shortly before transplanting time. About 2 weeks before transplanting to the field, plants are hardened to withstand the move. Care is required here: overhardening can be harmful, and plants should not be allowed to suffer severely from lack of moisture.

Transplanting. Plants are ready to transplant when they are 4 to 6 inches high and about ¼ inch in diameter, but planting dates vary in different districts. In some areas, the dates are restricted by an order adopting California Department of Agriculture regulations pertaining to host-free districts and periods (western celery mosaic). The counties of Los Angeles, San Luis Obispo, and Monterey have the following host-free (celery-free) periods outside of greenhouses: Los Angeles County, July 11 to September 30; San Luis Obispo County, January 1 to February 14; Monterey County, January 1 to January 31. Growers should check with the Agricultural Commissioner to get data on additional regulations on districts.

Celery transplants are set in the field by machine or by hand. Some growers believe that hand transplanting in the field is faster, but most agree that machine planting has certain advantages: it enables a small crew to plant large acreages more easily and efficiently and it places plants into moist soil at a uniform depth.

Celery may be transplanted on single or double-row beds. On a single-row bed, plants are spaced 5 to 8 inches apart in rows 24 to 40 inches from center to center. On a double-row bed, they are spaced 7 to 10 inches apart; the beds are 40 inches from center to center and are usually ridged, with the plants set halfway up the sides of the furrow. "Scratching" (a hand-weeding process) and cultivating are done later to control weeds and reshape the beds so that rows are on top and not in the furrow. Plants are sometimes set in bottoms of furrows and it is customary (especially during hot weather) to run small streams of water slowly down the furrows as plants are being set. Occasionally, plants are placed on flat top beds as in direct-seeding.

If 350 flats, averaging about 100 plants each, are planted per acre, approximately 40 man hours per acre are required to transplant.

Direct-seeding. Seed is placed ¼ to ½ inch deep with a small-seeded vegetable planter, using 1 to 1½ pounds of seed per

Continued on page 14

CELERY SEEDLINGS in an Oxnard greenhouse. These plants are about ready for transplanting into the field—some will go to the Arroyo Grande area and some farther north to Salinas.

The transplant operation

IN THIS GREENHOUSE operation, soil from the pile in background is put into flats which are then placed in the sterilizing apparatus. Note how top of sterilizer fits into a slot to seal the chamber.

TRANSPLANTING SEEDLINGS into a field near Arroyo Grande (above). These plants were grown in a greenhouse in Oxnard and shipped north the day before transplanting. Transplants may also be set by machine.

RIGHT, CLOSE-UP OF TRANSPLANTING operation. Irrigation water is run down furrows as seedlings are transplanted. Workers dip roots into water before placing them into soil alongside the furrow.

IRRIGATION AFTER TRANSPLANTING (below right) gives new plants more chance to overcome shock of handling.

DIRECT SEEDING with a regular small vegetable seeder in a single row operation near Arroyo Grande.

Direct seeding in the field . . .

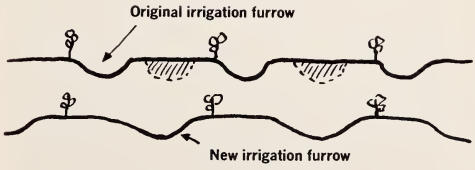
THINNING WITH HAND HOES. Workers on a planting near Salinas are chopping out unneeded plants, leaving remaining plants at 5 to 10-inch spacings.

DOUBLE-ROW PLANTINGS are characteristic of the Salinas area. Plot at the left was direct-seeded, then thinned by hand.

. . *requires later thinning*

CULTIVATOR AT RIGHT will be used to form new irrigation furrows as explained below.

THE SKETCH BELOW shows how original irrigation furrows are filled with soil taken from new furrows.



acre. Generally, a seeding sled equipped for planting two, three, or four beds at a time is used. Double rows, 12 to 14 inches apart, are used on beds 40 inches apart. Soil around seeds must be kept moist enough for good germination, though this is usually difficult to do. In the Salinas Valley, emergence requires 12 to 25 days.

When the small plants have 4 to 6 true leaves they should be thinned, leaving 5 to 10 inches between plants.

FERTILIZATION

Heavy fertilization is often necessary for maximum yields and top quality, and amounts used depend largely upon soil type and previous cropping practices. Sandy soils are generally lower in fertility than are heavy soils and require more fertilizer. Data on nutrient absorption of celery in several commercial fields showed that the crops removed about 280 pounds of nitrogen, 72 pounds of phosphorus, 635 pounds of potassium, and 35 pounds of magnesium per acre. Over 45 per cent of the nutrient uptake of each crop was absorbed during the 28 days immediately preceding harvest.

Although a complete fertilizer (nitrogen, phosphorus, and potassium) can be used, nitrogen has the most pronounced effect on growth and stimulates the production of vegetative parts of plants. In general, total amounts of nitrogen applied vary from 200 to 400 pounds per acre. If phosphorus and potassium are known to give response, or to be deficient, 200 pounds of P_2O_5 and 200 pounds of K_2O per acre should be added to the pre-plant fertilizer.

Nutrient sprays, including magnesium, boron, and calcium are sometimes needed. A series of calcium nitrate sprays helps prevent blackheart. (See "PHYSIOLOGICAL DISORDERS," page 24).

CULTIVATION AND WEED CONTROL

To control weeds, loosen crusted soils, and re-shape beds so that rows are on top of the beds and not in the furrows, the field should be cultivated 3 or 4 weeks after transplanting. Direct-seeded fields generally are cultivated before and after thinning; thereafter, only shallow cultivation should be practiced, as deep cultivation cuts off roots. Some hand weeding will probably be necessary, and complete control is necessary for maximum yields and quality of celery. In the Salinas Valley, four cultivations may be necessary.

Oil sprays, such as carrot oil (350° thinner) or Stoddard solvent, have been used successfully for weed control on young plants (those having 2 to 3 true leaves) in direct-seeded fields; 20 to 40 gallons per acre are satisfactory. (See your local Farm Advisor for the latest recommendations on weed control.)

IRRIGATION

Tenderness and succulence in celery depend largely on a good moisture supply. Celery is shallow-rooted and frequent irrigations are necessary throughout the growing period if seasonal rains are insufficient. The frequency and amount of irrigation needed for best growth varies with soil type, air temperatures, and amount of rainfall. Frequent irrigations are needed right after transplanting, but after plants have become established irrigating can be done every 10 or 14 days, or less during a rainy season. As the crop nears maturity, irrigations should be made about once a week, particularly on sandy soils. Water requirements are particularly heavy during the last month of growth, when it is often necessary to irrigate every third day.

In the Salinas area, water is applied immediately after seeding until beds are thoroughly wet. One or two additional irrigations are usually required until emergence is complete.

Furrow irrigation is used predominantly in California.

ROTATION

Intensive growing of celery on the same

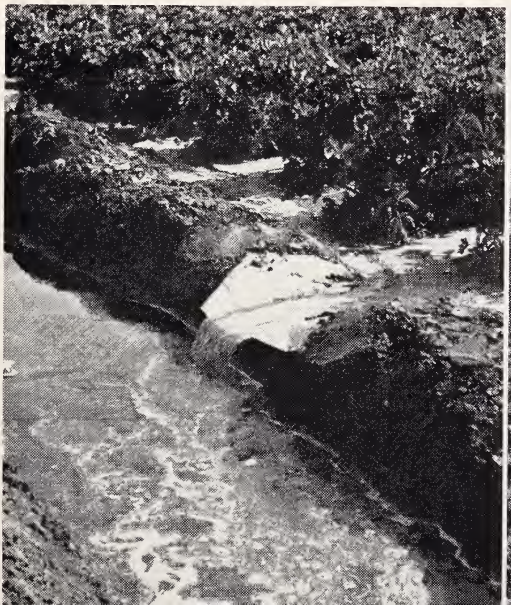
land for many years has reduced production in some areas to an unprofitable level. The main cause of low production is a build-up of soil-borne pests and diseases—such as nematodes, late blight spores, and fusarium wilt—but soil compaction may also become a problem.

Rotating crops, or growing green manure crops, helps to maintain high production and allows better use of the soil resources. In some districts one crop of celery a year is grown in rotation with a summer crop such as lima beans, tomatoes, broccoli or cucumbers.

DRILLING FERTILIZER with the same machine used for cultivation. In this operation near Arroyo Grande, the cultivator teeth are raised as fertilizer from the hoppers is drilled between rows.

Cultivating . . . fertilizing . . . irrigating

EROSION IS MINIMIZED by the use of paper at the low end of this field near Oxnard.



HALF-GROWN PLANTS in a planting near Arroyo Grande irrigated from pipeline system.

Harvesting

Sound harvesting procedures are particularly important for the celery producer.

The greater share of celery production cost is in harvesting and packing. Harvesting itself is usually done by hand, although attempts are being made to mechanize it.

Celery can be prepared for the harvesting crew by cutting roots off just below the crown with special knives mounted on tractors. Marketable stalks should be trimmed in order to remove sucker growth and old outside leaves. The hand-knife method of cutting and stripping is still popular, although several machines which cut the roots and cut off leaves at a uniform height are now used. Crates can be packed for market in the field, but as a rule celery is hauled to the packing house for grading, washing, and packing.

Various methods of handling and transporting cut celery are now used. Among them are (1) packing into field crates, (2) hand-loading into baskets on trailer, (3) hand-loading into baskets on ground, (4) conveyor-loading into baskets on trailer, and (5) hand-loading into bulk trailer. A study of these methods showed that conveyor-loading into wooden bins on a trailer was the most economical, but was also the most damaging to petioles. The bulk methods studied were faster and less expensive than hauling celery in field crates to the packing shed.

Packing, Marketing, Storage

There are several ways to handle harvested celery, and new methods are being developed.

In the packing house, celery is washed thoroughly, cut to uniform length, and moved by conveyor belt through trimming, sorting, and washing operations. Stalks are sorted into five different sizes, ranging from 1½ to 4½-dozen stalks per crate, before being crated, labeled, and loaded for shipment. The 2, 2½, and 3-dozen sizes are the most common.

Celery—especially spring and summer celery—should be precooled to remove heat soon after it is harvested; the sooner this is done, the longer the plant's market life. The most common method of precooling employs an ice-water bath, and is known as "hydrocooling." Celery may be conveyed through the bath, or packed in *crates* and then hydrocooled. In precooling, temperatures should be brought to as near 32°F as possible—though in practice temperature reduction is often only to 40 or 45°F. In hydrocooling, the water temperature increase should be minimized, and sufficient time allowed for cooling; temperatures at crate centers must be checked occasionally. Vacuum cooling is used if celery is packed in *cartons* for long-distance shipping.

Containers for celery stalks are usually about 16 inches in one dimension, since most stalks are cut to about that length. Common dimension of cartons are 10 × 11 × 16 inches, and each carton may contain 12 to 18 stalks. Containers include wire-bound crates (9¾ × 16 × 20¼ inches), nailed sturdy crates (9¾ × 16 × 19 ¼ inches), and fiberboard cartons; average weight of the packed wire-bound and nailed crates is 60 pounds, and that of the cartons, 32 pounds. Water cooling cannot be used with carton-packed celery because the container would absorb water and collapse, nor can such shipments be top-iced. Carton-packed celery for long-distance shipment is therefore vacuum cooled and freshened with cold water before displaying.

Celery is sometimes placed in film bags with the tops left open, and this may be done at shipping or terminal point. Celery hearts are packaged in bags of cellophane or polyethylene, or on trays overwrapped with film.

Celery may also be field packed, and recently a portable packaging machine for film-wrapping celery in the field has

been developed. Self-propelled and equipped with six semi-automatic wrapping machines, this field unit requires twelve cutters to harvest and trim the celery, six to eight other persons to place "setups," act as quality controllers, and select and sort the stalks and place them on the unit for wrapping, six wrapping-machine operators, and two to four men to receive the wrapped celery and pack it in a special corrugated carton. This last operation takes place on a truck towed behind the wrapping unit.

Storage. Celery can be stored for a period of 2 to 3 months if care is used. Humidity should be high (90 to 95 per cent) to prevent wilting, and storage temperature should be between 31 and 32°F. There should be sufficient air movement to maintain uniform low temperatures, as celery may heat because of respiration. The plants make some growth in storage at the expense of the food stored in the stalks, and some blanching may also occur. The celery can be trimmed and washed just before it is put on the market.

END-TO-END pack is preferred by some growers. These crates will be hauled to a shed for final packing before shipment.

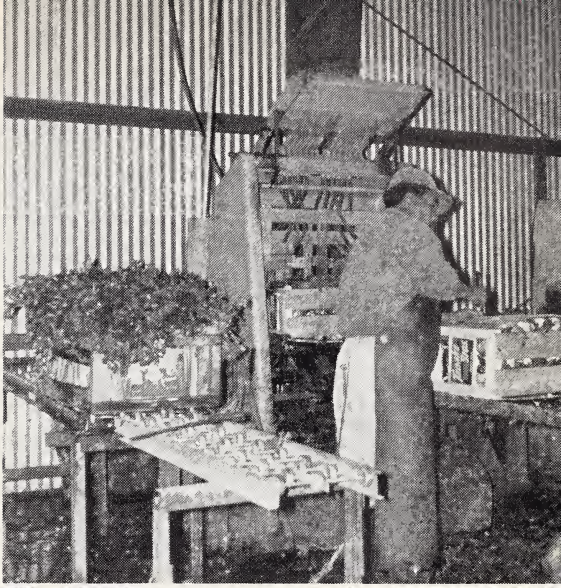
MACHINE TOPPING near Oxnard. Plants are topped by a mower with its cutter bar raised to a convenient height.

MACHINE-TOPPED PLANTS are then harvested and placed in large bins which are forklifted to waiting truck.

PALLETIZED CRATES are used in this operation near Oxnard for moving cut celery from field to packing shed.

THE PACKING OPERATION. Celery in the foreground is moving away from the camera; the celery will go through washer (far right) and back along conveyor. Packers line the crates, pack them with celery, and put them on another conveyor that will take them to the lidder.

berations



THE FOIL WRAP is preferred by some packers. Here lids are put on by machinery; leaves sticking out of crate are hacked off.

A HYDROCOOLER removes field heat left in celery after it is packed and before it is shipped. The cooler operator also trims off leaves that stick out of the crate.

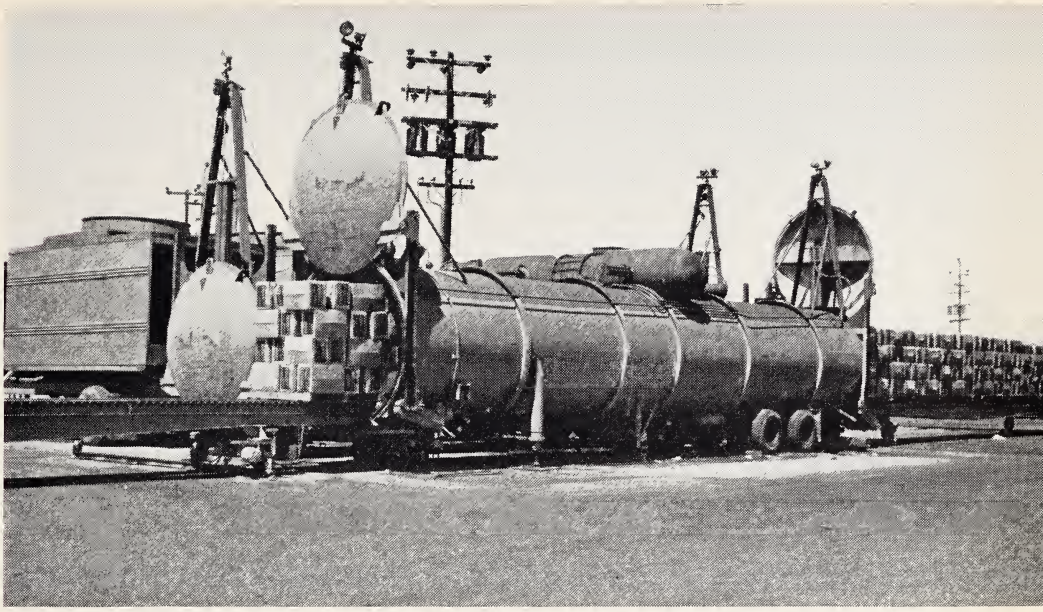
REFRIGERATED CARS are used for shipping celery. Crates being loaded aboard the car have just come out of the hydrocooler shown above.

IN FIELD PACKING each worker packs but one size stalk, leaving others for following worker.

SPRAYING PACKED STALKS with water—moisture will be removed later by vacuum cooling.

Field Packing Operations

LIDDING EQUIPMENT for cartons (left) or crates is portable and can be used in the field to permanently close containers.



VACUUM COOLERS handle a truckload of cartons at a time. When celery is cooled, ends of coolers come up so that load going in (extreme right) pushes out the cooled cartons, which are then fork-lifted to near-by railroad car.

Diseases

How to recognize them, and what to do about them.

Prevention is the best way to combat celery diseases successfully. Many of the more common celery diseases can be prevented, or controlled, by systematically resorting to seed treatment, seedbed and field sanitation, and field application of fungicides.

Late blight. Late blight, also known as "Septoria leaf spot," is caused by *Septoria apiicola*, and is prevalent on fall, winter, and early spring crops. The disease appears first as small yellow areas, which gradually enlarge and turn brown. Minute black specks—the fruiting structure of the fungus (pycnidia)—develop in the dead tissue of the lesions, and severely-diseased plants develop similar lesions on their petioles. Under favorable conditions for infection and disease development, the fungus penetrates the host and produces visible symptoms in approximately 9 to 12 days. Disease development is favored by cool, moist weather. The fungus is seed-borne and may live in infected celery refuse for as long as 18 months. Fungicide sprays such as zineb, maneb, dyrene, bordeaux mixture and fixed coppers are effective for the control of this disease. (See "*Growing transplants in the greenhouse*," page 8. For further information, see California Plant Diseases—University of California Agricultural Extension Service Publication 1, AXT-75, "Late Blight of Celery.")

Early blight. Early blight is caused by the fungus *Cercospora apii*. It is much less important in California than late blight, but may develop in warm weather when humidity is high. Control treatments should begin when the disease first appears. It is sometimes necessary to start treatment in plant beds or flats in the greenhouses; in other cases, the disease

SAMPLE COSTS PER ACRE TO PRODUCE WINTER CELERY—DOUBLE CROPPED

(Yield = 1,000 crates per acre; Orange County, 1962)

OPERATION (CULTURAL)	HOURS PER ACRE	CASH AND LABOR COST PER ACRE				
		LABOR	FUEL AND REPAIRS	MATERIALS		TOTAL
		dollars	*dollars*			*dollars*
Disc 3 times, 40 HP track, 10½′ disc	1.0	1.65	3.35			5.00
Subsoil, 40 HP track, 2 point	1.0	1.65	3.05			4.70
Plow, 40 HP track 3/16″	0.6	1.00	2.00			3.00
Disc 5 times, 40 HP track, 10½′ disc	1.7	2.80	5.70			8.50
Landplane 2 times, 40 HP track, 10′ × 40′ plane	0.6	1.00	2.00			3.00
Fertilizer applied	...	....	....	Chicken manure, 800 cu. ft.	72.00	72.00
Pinkrot control	...	....	....	Cyanamid, 900 lb. applied	44.00	44.00
Disc 2 times, 40 HP track, 10½′ disc	0.7	1.15	2.35			3.50
Chisel and harrow 2 times	0.7	1.15	2.20			3.35
Furrow out, 20 HP wheel, 3 row	0.5	0.85	1.15			2.00
Plant	37.5	41.25	....	Plants, 350 flats @ $.65	227.50	268.75
Irrigate 11 times	11.0	13.75	....	Water 2′ @ $15.00	30.00	43.75
Scratch	20.0	22.00	....			22.00
Cultivate 7 times, 3 men, 10 HP wheel, 2 cult	4.5	22.35	9.00			31.35
Fertilize 2 times, 20 HP wheel, 4 row	1.0	1.65	2.25	8-8-4 2 tons @ $55	110.00	113.90
Dust 2 times, 10 HP wheel, 8 row	0.4	0.65	0.80	DDT 5%, Toxaphene 15%, and Parathion 2%, 50 lb. @ 22.50	11.25	12.70
Spray 3 times, 20 HP wheel, 300 gal.	1.5	2.50	4.35	Copper 75 lb. @ $.40, and Parathion 1 gal. @ $12	42.00	48.85
Weed 2 times	6.0	6.60	....			6.60
TOTAL CULTURAL COST PER ACRE		122.00	38.20		536.75	696.95
Miscellaneous overhead					35.00	
Taxes, ½ of $80					40.00	
Management, 5% of $1,750					87.50	

Investment	Per acre	Depreciation	Interest	
Land	5,000	....	300.00	
Equipment	275	27.50	8.25	
Total (½ depreciation and interest)		27.50	308.25	167.90
TOTAL PRE-HARVEST COST PER ACRE				1,027.35
Cut, trim, pack, haul, brokerage @ $1.55 per crate				1,550.00
TOTAL COST PER ACRE				2,577.35
COST PER CRATE AT 1,000 CRATES PER ACRE				2.58

does not appear until celery is fairly well grown. Spray application of fungicides is more effective than dusting. The old standard control measure is sprays of 5-5-50 bordeaux mixture repeated every 10 to 14 days, but recently zineb and maneb sprays applied every 7 to 10 days have proved very effective.

Celery mosaic. Several virus diseases may cause mosaic symptoms on celery. The most important, *western celery mosaic,* causes a clearing of the veins followed by mottling, brown spotting, and twisting or cupping of the leaflets. White spots or streaks develop on the petioles and the plant becomes stunted. A highly destructive disease spread by aphids, it has been found in all the large celery districts of the state.

The best method of controlling western celery mosaic in a district is to establish a celery-free period during which no celery is allowed in the district; Los Angeles, San Luis Obispo, and Monterey counties have legally established such periods. Mosaic is much less serious in the interior valleys than it is in the coastal areas, where celery can be grown most of the year.

Aster yellows. Aster yellows is another virus disease. Leaves of affected plants are twisted, stunted, and yellow. The disease is spread by the six-spotted leafhopper, and other species of leafhoppers, and has a wide host-range.

Pink rot. Pink or cottony rot, which is caused by *Sclerotinia sclerotiorum,* causes much loss of celery in California. Soft water-spots develop on the outer petioles at the base of the stalk and gradually work upwards. A white cottony fungus, in which black bodies called "sclerotia" may be seen, grows on the surface of the petioles, and affected tissues often show a light pink color; badly diseased plants may wilt and eventually die. Humid conditions favor the fungus, and it grows best

in moderately warm temperatures. (See "PREPARING THE SOIL," page 7.)

Miscellaneous diseases. Other diseases attacking celery are: gray-mold, bacterial soft rot, fusarium yellows, and phoma root rot.

Physiological Disorders

How to recognize certain plant diseases not caused by pathogenic organisms.

Blackheart. This disorder causes the growing tips in the celery heart to die and turn black. Calcium nitrate sprays are recommended for treatment at the rate of 15 pounds of calcium nitrate per 100 gallons of water per acre—preferably at weekly intervals, or as indicated by frequent field observations. The spray must be applied to the heart of the plant so as to wet young crown leaves thoroughly. High temperatures, rapid growth, and lack of water are often associated with blackheart. Excessive soil salinity and nitrogen are also believed to favor blackheart.

Brown checking. The principal characteristic of this disorder is a brown-russeted necrotic development on the inner face of the petiole. This brown tissue usually develops below the first leaflets and extends down about one-half to two-thirds of the petiole shank. There is no evidence of damage to leaflets or to the upper parts of the petiole, and the outer surface of the petiole is seldom damaged. Brown checking appears most often in celery at advanced stages of growth, and often is not noticed until after harvesting is started. Studies have shown that brown-checked celery has a low boron content, that the petioles of affected plants are high in potassium, and that the Utah 10-B variety seems to be highly susceptible to this disorder. Boron sprays have been effective on young plants at the application rate of ½ pound of actual boron per acre when there are reasonably good leaf surfaces to absorb it.

Magnesium yellowing. The yellowing of older leaves of green celery varieties due to magnesium deficiency has been observed in California. The interveinal areas of the leaves fade a little faster than the veins. Varieties differ in their susceptibility to yellowing, but Utah 10-B and Utah 16-11 are particularly susceptible. Varieties of the Utah 52-70 and D5 types are less susceptible to magnesium deficiencies than other varieties used in California. This deficiency can be prevented by spraying plants weekly with magnesium sulfate (Epsom salts) at the rate of 10 pounds per 100 gallons of water per acre. Soil applications of magnesium have not been effective.

Insects

How to recognize insect and mite pests, and some suggestions for controlling them.

INSECTS AND MITE PESTS seldom cause widespread damage to celery in California, although localized infestations of several species may occur. Troublesome insects and mites are listed below.

Aphids. At least 11 species of aphids are capable of transmitting celery mosaic. The most common species are the rusty-banded aphid, the cotton or melon aphid, the lily aphid, and the green peach aphid. Presence of these aphids is generally revealed by their droplets of honey-dew, and by the sooty mold which grows on the droplets.

Spider mites. These small mites feed and spin webs on the under sides of leaves, but the whitish-yellow spots caused by their feeding develop on the *upper* surfaces of leaves. Field infestation, which is most likely to occur in hot, dry weather, begins in small areas (often near dusty roads) and then spreads. It is important to apply miticides when mites first appear.

Celery leaf tier. Leaf tier larvae are about ½ inch long, are pale green with white or yellow stripes, and have two black spots on the sides. The caterpillar webs leaves together, and feeds on the foliage and leaf stalks; its small white eggs are deposited on the under side of the celery leaves.

Six-spotted leafhopper. The six-spotted leafhopper transmits the aster yellows virus and must be controlled if the disease is to be prevented.

Cutworms, armyworms. Cutworms feed on young plants, usually soon after transplanting, and may cut off leaf stalks just above the crown. They are dull gray, brown or black, and may be striped or spotted. They are stout, soft-bodied, smooth, and up to 1¼ inches long; they curl up tightly when disturbed. Armyworms feed on stems and foliage. Their larvae measure up to 1½ inches in length, and are usually greenish in color with three longitudinal dark to yellowish stripes on each side.

Loopers. The cabbage looper is often a damaging pest in interior valleys and in some coastal areas, particularly in late fall, and requires constant watching and application of insecticides. These smooth-skinned green worms feed on foliage and petioles, and are easily recognized by their looping walk.

Leafminers. Fly larvae of the genus *Liriomyza* may, when abundant, cause severe damage by making serpentine mines in leaves and stalks.

Other insect pests are occasionally of importance. The western *parsley caterpillar,* which is large and beautifully marked with green, black, and orange, feeds on foliage of celery. Immature stages of the *white fly* sometimes live on the under side of celery leaves, causing them to become dark and sticky; this pest may require several insecticide applications before control is achieved. The *lygus bug* often leaves feeding and oviposition scars on celery stalks. The *vegetable weevil* has been known to damage celery.

Root-knot nematode. This soil pest sometimes develops on celery in warm weather. Affected plants are usually stunted, and roots show numerous irregular galls or swellings. Infested plant-bed sites should be avoided and infested fields should be fumigated before using. Examination of roots of susceptible crops preceding celery may indicate a need for soil fumigation to control nematodes.

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